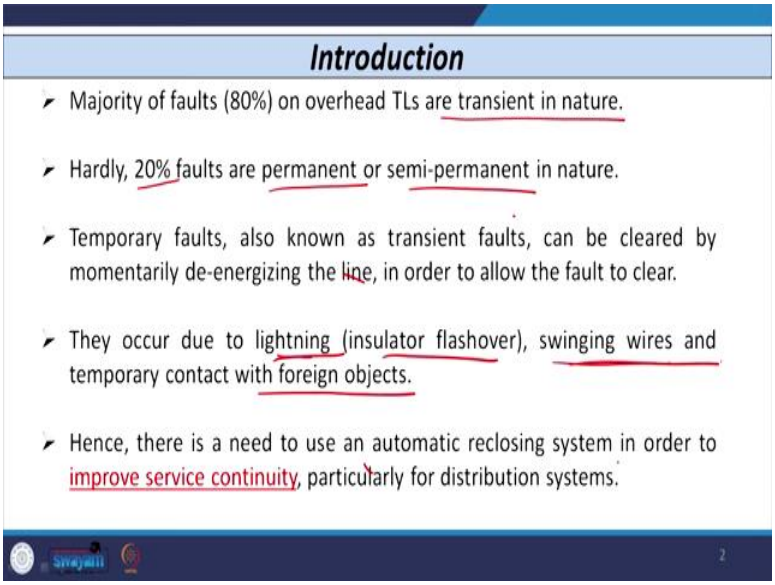
Power System Protection and Switchgear
Professor. Bhaveshkumar Bhalja
Department of Electrical Engineering
Indian Institute of Technology, Roorkee
Lecture No. 23
Auto-reclosing and Synchronizing-I

So, in this class we will discuss regarding the auto-reclosing and synchronizing feature that is useful particularly in case or protective device and circuit breaker.

(Refer Slide Time: 00.45)



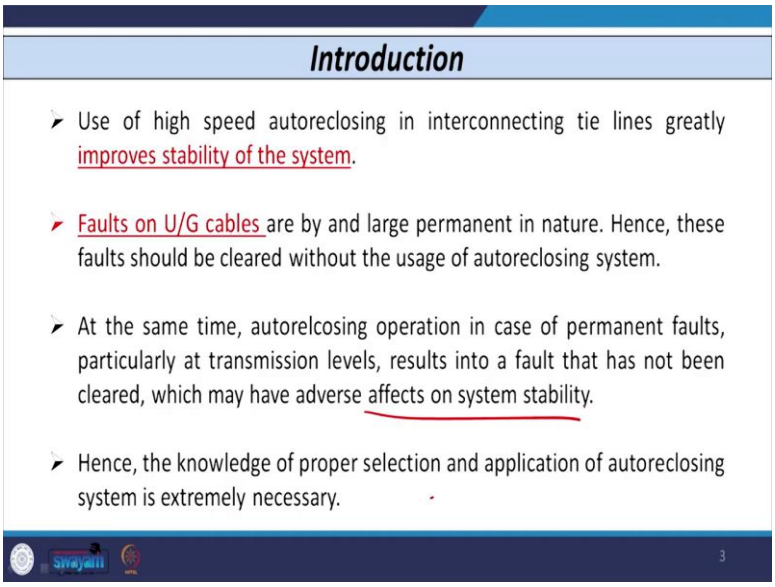
Now, we know that the majority of faults that is 80% faults on overhead transmission lines that is transient in nature that means this faults may die out after some time. So, hardly we can say that hardly 20 percent of the faults that are either permanent or semi-permanent in nature. So, we know that temporary or transient faults that can be cleared by momentarily de-energizing the line. So, whatever fault is there that may not exist once we de-energize the line momentarily after the opening of the circuit breaker.

So, this transient faults may occur due to maybe the lightening that is flashover of insulator, this type of faults may occur because of swinging of wires or maybe when some temporary contact curves with some foreign object. So, because of these reasons, such type of faults that may occur on overhead conductors. So, in this situation if we wish to clear this transient fault or temporary faults, then there is a need to use an auto-reclosing system.

Because if we use this system, then that will improve the service continuity particularly, as far as distribution system is concerned, this will also improve the stability and reliability of

the system when we consider the transmission system. So, use of high-speed auto reclosing in tie lines where any big tie lines that is connected between two two areas, then we can definitely improve the stability of the system if we go for or if we adopt high-speed auto-reclosing system.

(Refer Slide Time: 2:30)

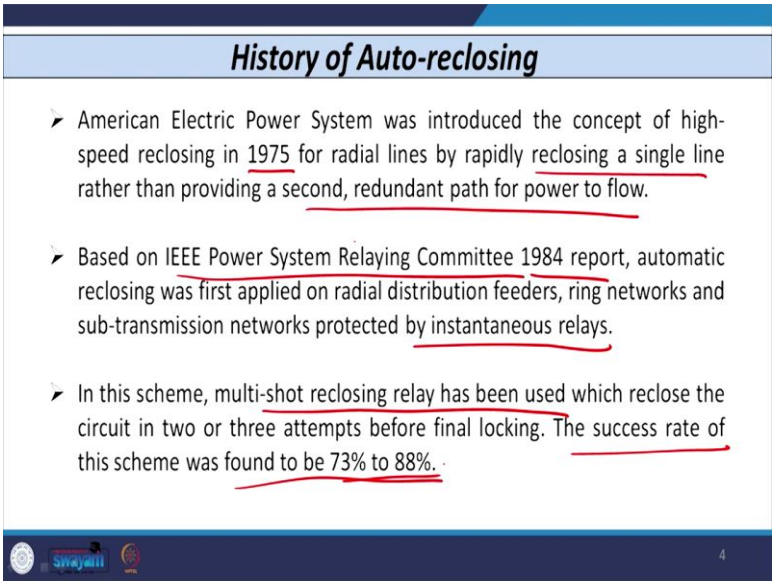


One more important point that we know that faults on underground cables are usually permanent in nature. Hence, for such type of means, this type of faults do not need auto-reclosing system. So, we have to use the auto-reclosing system only for overhead conductors and we should not use such type of system for underground cables.

Now, at the same time, auto-reclosing operation in case of permanent fault, suppose if fault is permanent, because we do not know whether fault is permanent or transient. So, if fault is permanent in nature and if we adopt, if we use auto-reclosing system, then that may give a bad impact on the contact of the circuit breaker, and sometimes in worst case that may also affect the stability of the system.

So, that is why the knowledge of proper selection and application of auto-reclosing system that is very important.

(Refer Slide Time: 3:32)

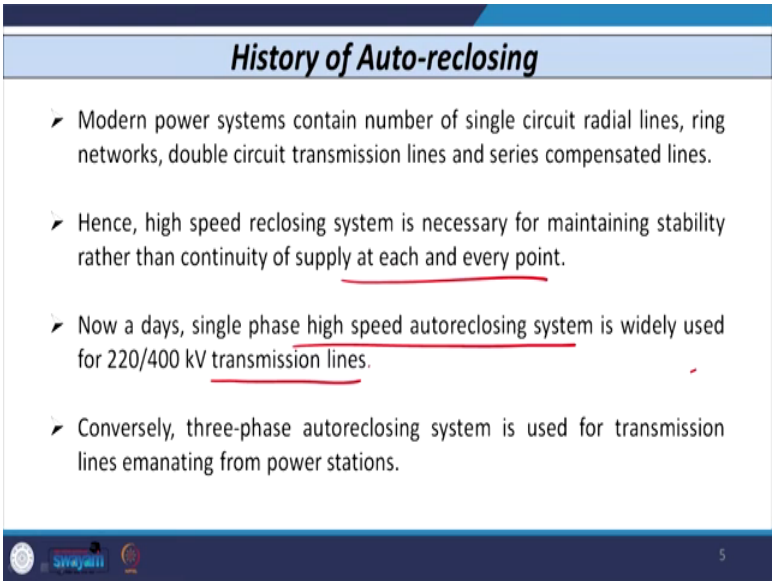


So, let us discuss what is the history of auto-reclosing, and how we can apply it. What are the different types of auto-reclosers? So, if I just go into the history, then the first time in 1975 American Electric System they were introduced such type of system for a radial distribution network. So, in case of radial distribution network by adopting this feature that means by utilizing the reclosing the continuity of the supply that can be improved.

If I go further then IEEE Power System Relaying Committee in 1984 report, also mentioned that this type of auto-reclosing system that can be applied on radial system, ring networks and maybe sub-transmission and on transmission network also by utilizing instantaneous relays. So, whether we use instantaneous overcurrent relays or we use or we go for distance relays for first in first zone or we go for some pilot relays.

So, in this scheme, they use the multi-shot reclosing relay that means, the reclosing that is to be adopted or carried out multiple times to reclose the circuit and the success rate of this scheme that is found around 73 to 88 percent. So, the continuity of service and stability of the system that is increased tremendously and hence, the auto-reclosing means, application of auto-reclosing that is very important as far as the transmission and distribution line is concerned.

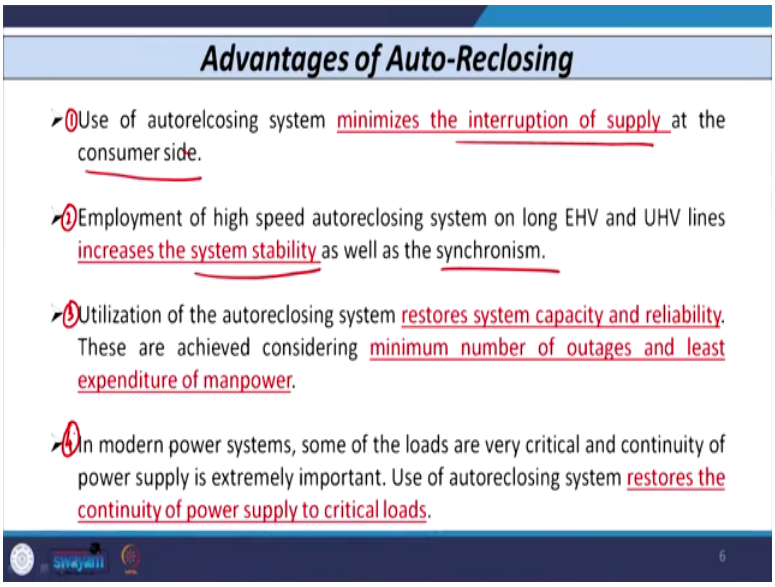
(Refer Slide Time: 5:12)



Now, we know that the modern power system contains also number of radial lines, ring networks and double circuit and series compensated line. So, high speed reclosing that is necessary to maintain the stability rather than the continuity of supply at each and every point. So, if I consider the auto reclosing system then it depends on for what type of application we are utilizing it.

Nowadays, we we are also utilizing the auto-reclosing, system high speed or auto-reclosers particularly for 220 and 400 kV EHV and UHV lines. On the other hand, the three-phase autoreclosing system is used for transmission lines, which emanating from the substation.

(Refer Slide Time: 6:00)



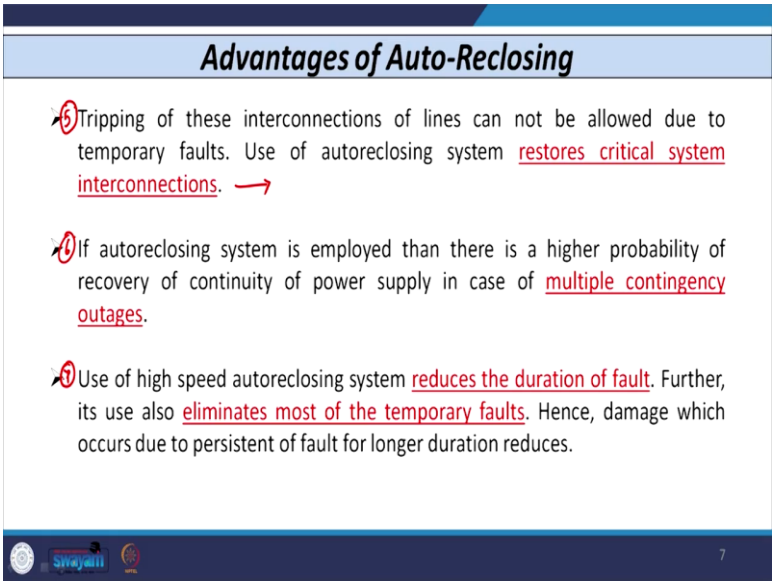
So, let us see what are the advantages of autoreclosing system. So, very first advantage of autoreclosing system that is the it minimizes the interruption of supply at the consumer side. So, because whenever we go for a reclosing attempt, then if faults are transient in nature, and as we know that the 80 to 90 percent faults are on overhead conductors are transit temporary so this faults may die out after the first reclosing time, and the supply or the electric supply that continues. So, the interruption of supply that is minimized as far as customer viewpoint.

The second advantage of auto reclosing system that is the, if we go for a high speed autoreclosing system for EHV and UHV line, then that will improve or increase the system stability as well as the synchronization of the network. So, this is also the another advantage of autoreclosing system. The third advantage of autoreclosing system that is the, if we use the autoreclosing system then that is capable to restore the system capacity and reliability. So, this can be achieved by considering minimum number of outages and the least expenditure on manpower.

We know that if we go for reclosing capital and when the faults are transient in nature or temporary data, so there is no need to send the line man so expenditure on manpower that can be reduced number one, and as faults are transitive nature, so maintenance is also not required that means, when we deal with without the autoreclosing system, then we can say that the number of outages that can be also reduced. So, this is also the another important advantage that it reduces the number of outages, as a well as the expenditure on manpower.

The fourth advantage of autoreclosing system that is the, we know that some of the loads in our power system network that is very critical, for example, hospitals, military loads, so we need to give interrupted power supply. So, if we use the autoreclosing system then that is, that restores the continuity of supply for all such type of critical loads. So, this is also one of the important advantage.

(Refer Slide Time: 8:32)

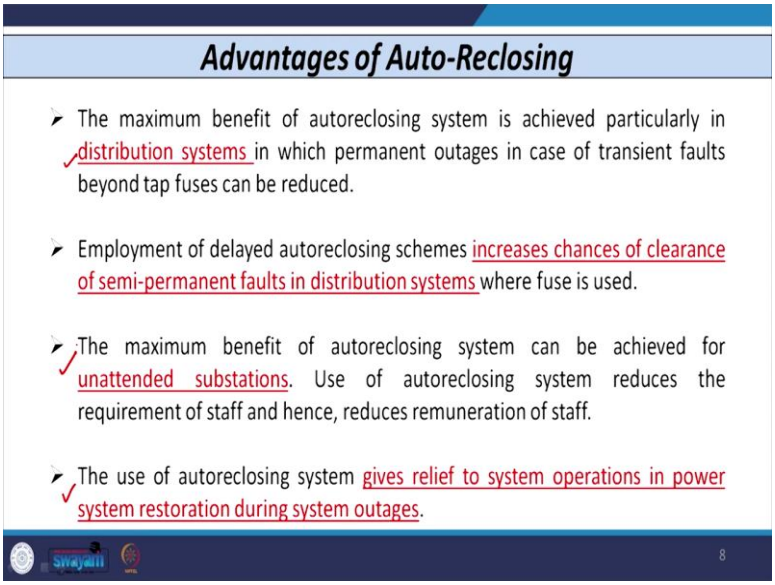


The other advantage of auto reclosing system that is we know that the tripping of the very long lines or tie lines, because in case of a temporary fault that is that will impact a huge on the stability of the whole power system network. So if we use the autoreclosing system, then that will also improve that not only improves the stability, but also restore the critical system interconnections for particularly for long EHV and UHV lines.

The other advantage of autoreclosing system that is the case of the multiple contingency outages, the autoreclosing use of autoreclosing system that is beneficial, and the other advantage of the autoreclosing system is if we go for high speed autoreclosers, then that will reduce the duration of fault, so the time up to which the fault persists or exist in the system that reduces.

So, further its use also eliminates the most of the temporary faults, hence, the damage that occurs because of the due to persistence of the fault for long time that also reduces. So, because of all this 6 or 7 advantages of autoreclosing system on the power system network, nowadays utilities are widely utilizing the autorecloser at distribution as well as the transmission level.

(Refer Slide Time: 10:05)

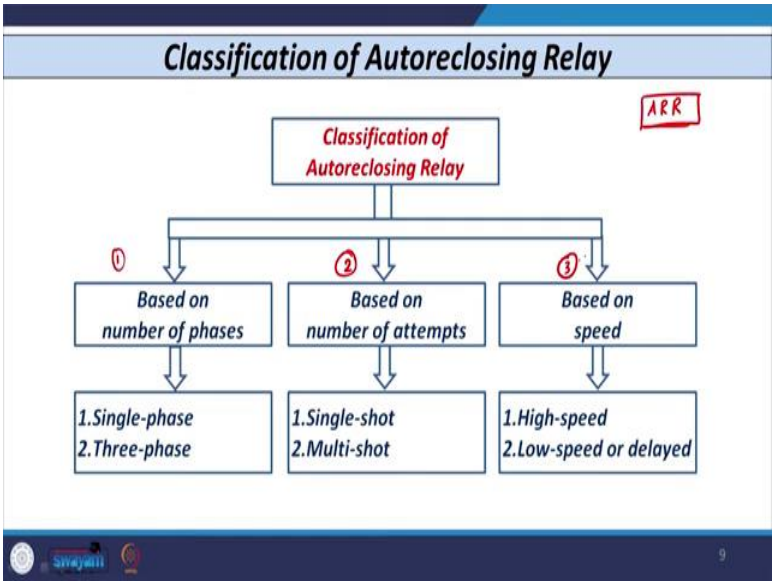


If I also list a few more advantages, then the major advantage that is for distribution system that is one thing, as well as the transmission system. Along with that this is also beneficial particularly when we go for the particular type of substations. We know that normally substations are of two types, one is known as attended substations and another is known as unattended substations.

So, attended substations are those substations it means the manpower is already there, whereas, unattended substations are those substations in which no manpower exist, so that is handled by all the automated devices. So in that case, in case of unattended substations also the benefit of autoreclosers that can be very good.

So, we know that because of all these advantages the utilization of autoreclosers that gives relief to the system operations in power system restoration also so when we know that when there is a partial or full blackout of the network and when we restore the system then in that case also the autoreclosers are helpful. So, this is also the another advantage of the autoreclosing systems.

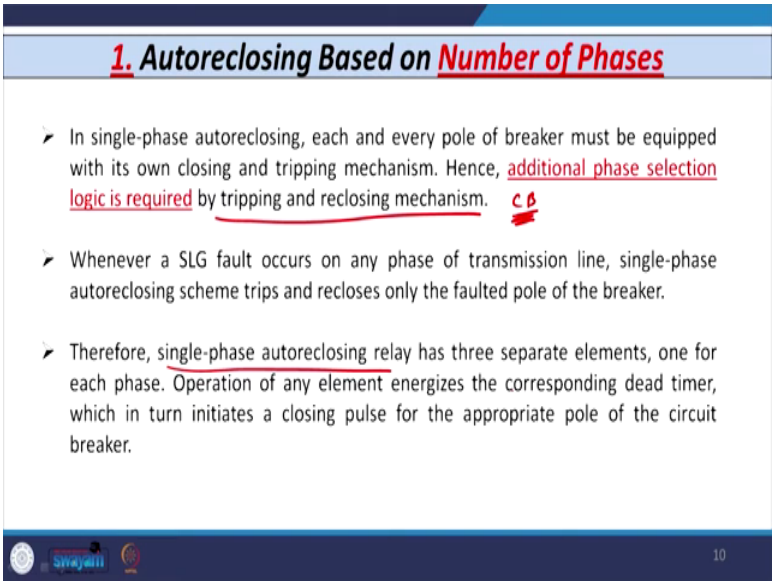
(Refer Slide Time: 11:28)



Now, with this background, let us see how we can classify the autoreclosing or system or autoreclosers. Normally, auto reclosers are denoted by the term ARR that is autoreclosing relay. So, let us see how this relays are classified. So, they can be classified based on the number of phases, whether we we want to utilize it for single phase or whether we want to utilize for all the three phases. The second way is based on the number of attempts, that means whether we we need to go for reclosing single time or we need to go, or we wish to carry out reclosing multiple times.

So, this is based on the number of attempts also we can classify and the third that is based on the speed. So, whether we wish to achieve high speed reclosing or whether we want to utilize for the low speed or delayed reclosing. So, let us consider each and every this autoreclosers that is based on phases, attempts and speed one by one.

(Refer Slide Time: 12:34)



So, let us start with the auto reclosing based on the number of phases. Now, in single-phase autoreclosing, each and every pole of the breaker that must be equipped with its own closing and tripping mechanism. We know that whenever we, we will see later on when we consider the chapters on circuit breaker, so circuit breaker has to use the mechanism for closing as well as the tripping.

So, it has certain coils and contacts. So, when when we use a single-phase (auto) autoreclosing then the additional phase selection logic that is also required for tripping and closing mechanism in case of circuit breakers. So, this is very important point, when we go for the single-phase autoreclosers.

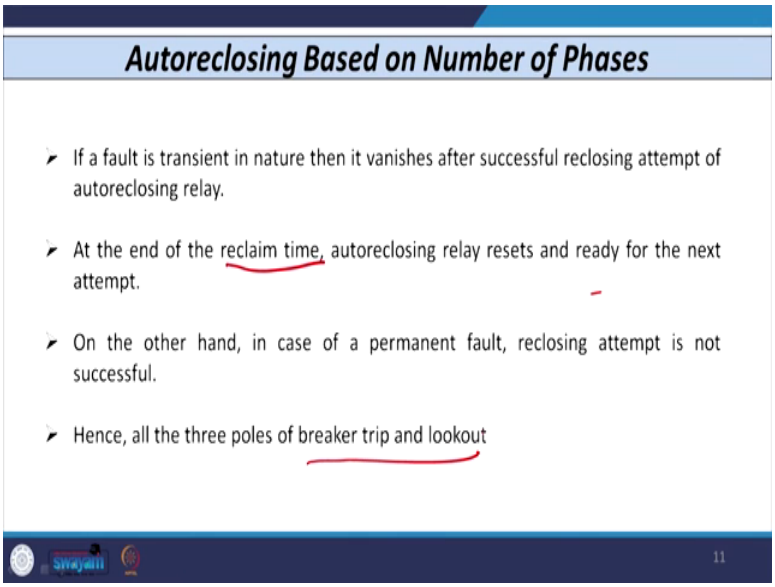
Whenever single line to ground fault occurs on any phase of the transmission line, the single-phase autoreclosing system trips and restores only for the faulted phase of the breaker that means, as I told you earlier, that when we discussed single-phase autorecloser in case of distance relay that if fault occurs in our phase, then our pole of the breaker that should open other two healthy phases that is Y and B phase that remaining close condition.

So, when we go for single-phase autoreclosing relay, then the single-phase autoreclosing relay has 3 separate elements, one for each phase and operation of any element energizes the corresponding timer, which in turn further gives the closing pulse for the appropriate pole of the circuit breaker.

So, when we go for single-phase autoreclosers, then we have to install it on per phase basis and these whatever circuitry that is required for each phase that is also applicable for other

phases also, so the the as far as cost is concerned, single-phase autorecloser that is slightly costlier than the three-phase autoreclosers. Now, if a fault is transient in nature then we know that it vanishes after successful reclosing attempt of autoreclosing relay.

(Refer Slide Time: 14:44)

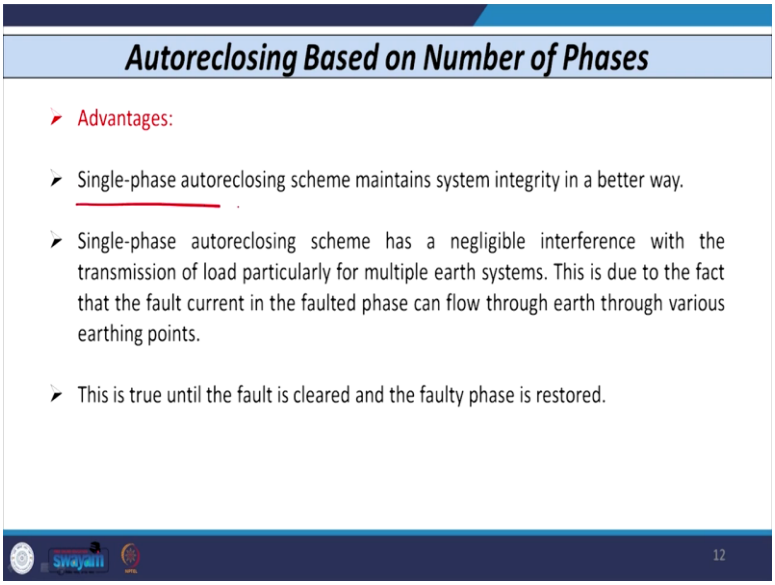


So, at the end of reclaimed time, now what is reclaimed time**,** that we will see later on just after 20, 30 minutes. The autoreclosing relay resets and ready for the next time. So, as we have discussed the protective device overcurrent relay, distance relay. So, wherever fault occurs, relay senses the fault and it gives signal to the breaker.

Wherever the breaker receives the signal, breaker, circuit breaker based on its mechanism operates and its contact separates then the arc is fully quenched, at that time after this instant, the relay resets. So, when relay resets so autoreclosers relay also needs resetting, so similar type of feature also persist or exist in case of autoreclosers also.

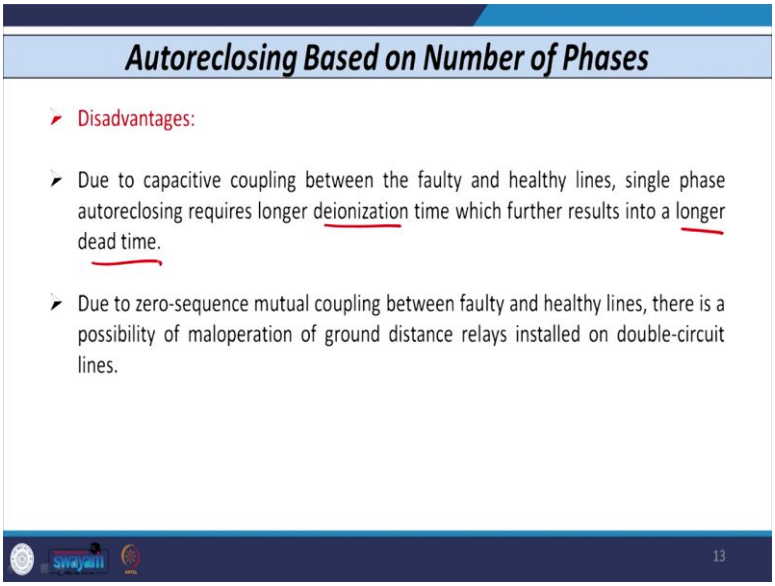
So on the other hand, in case of permanent fault reclosing attempt that is not successful, so all the 3 poles of the breaker that should again operate and that will finally go into the lockout condition. So, this we will discuss later on further.

(Refer Slide Time: 14:49)



Now, what are the advantages? So, single-phase autoreclosing scheme maintains the system integrity in a better way. If I use the single-phase autoreclosing scheme then it has negligible interference with the transmission of load particularly when we use multiple earth system, so this is due to the fact that the fault current in the faulted phase that can flow through the earth from various earthing points. So, this is also true until the fault is clear and the faulty phase that is restored. So, this is one of the biggest advantage of single-phase autoreclosing scheme.

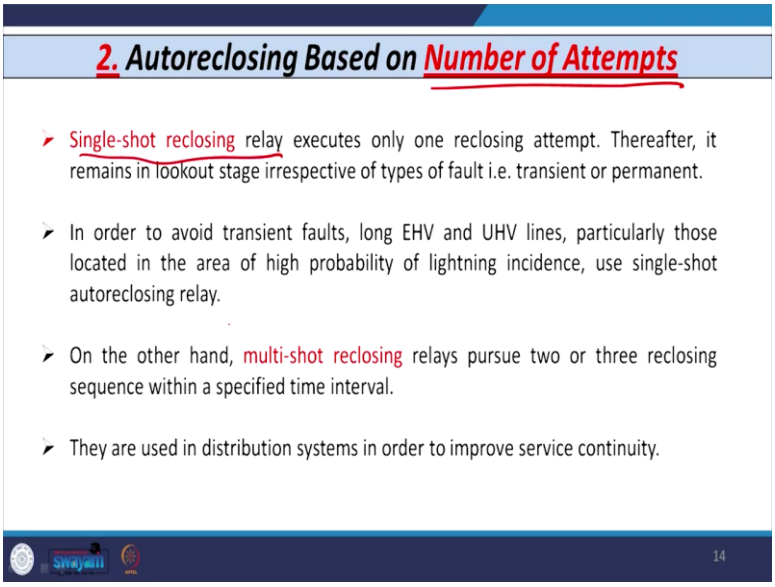
(Refer Slide Time: 16:28)



Let us see what are the disadvantages. So, due to capacitive coupling the faulty and healthy lines between this, so a single-phase autoreclosing requires a longer deionization time, which further results in longer dead time. Now what is deionization time and what is the dead time

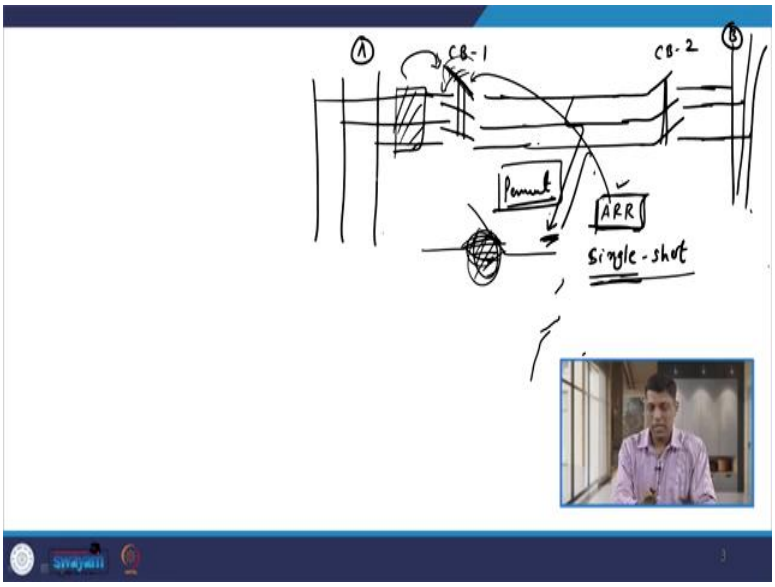
that we will discuss later on. Now due to zero-sequence mutual coupling that exists between the conductors, so there is a possibility of mal operation of ground distance relay, particularly, when we go double circuit lines so this is one of the disadvantage of the distance relay that when we use distance relay for double circuit lines that means, when 6 conductors are emanating from one bus then because of the zero-sequence mutual coupling effect the voltage is induced on the relay located on other parallel line and because of that, that relay may mal operate in case when particular type of fault occurs on this double circuit line.

(Refer Slide Time: 17:29)



So, with this background let us go for the next type of autoreclosing relay that is based on the number of attempts. So, whether we go for a single attempt or whether we want to utilize multiple attempts for the reclosing relay. Now, when we go for single-shot reclosing relay that means now how this scheme works.

(Refer Slide Time: 17:50)



So, if I just tell you, let us consider a conductor here and let us have the breakers also like this on the 3 pole. So, this is my circuit breaker at bus A. So let us say, circuit breaker 1 and then we have a line and then we have the another breaker at the other side say circuit breaker 2 and then we have a bus at substation B. Now whenever fault occurs on this line, transmission line, what what what is going on, whatever relay we have situated here at this bus this relay senses the fault and it gives signal to the breaker.

Circuit breaker whenever it receives the signal means whenever trip coil of circuit breaker receives the signal from the relay then it further give the tripping command, so its coil that is it gives command to the coil and hence the contact of the circuit breakers separates. As soon as the contact of the circuit breaker if I draw here one contact, whenever this contact separates, there is an arc across the contact of the circuit breaker.

And depending upon what type of circuit breaker we use, whatever the arc quenching medium we use this arc that is going to be quenched and when the arc, there is no arc across the contact of the or a pole of the circuit breaker that means, when contact of the breaker fully open at that time the function of autorecloser relay that starts.

So, then after the contact of the circuit breaker fully open that means, then there is no re-striking chances of re-striking of arc across the contact of circuit breaker, then the function of autorecloser starts. So now, the reclosing attempt with whatever we wish to made through

this autoreclosers, so this autoreclosers will give command further to the breaker coil and has the contact of the circuit breaker becomes closed.

And if fault is transient in nature, then the system is healthy, it is already die out, so it remains in close condition. If fault is in permanent nature, then again, this breaker opens again there is an arc, again this arc that is quenched depending upon the type of medium that is used in the breaker and again remaining open condition. So this is nothing, but the single-shot autoreclosers.

So single-shot means, once the breaker becomes open whatever reclosing attempt we made that is only one time so that is nothing but the single-shot autoreclosing relay. So, wherever we use single-shot reclosing relay that execute only one reclosing attempt, as I explained you, so it remains in lockout condition irrespective of type of fault.

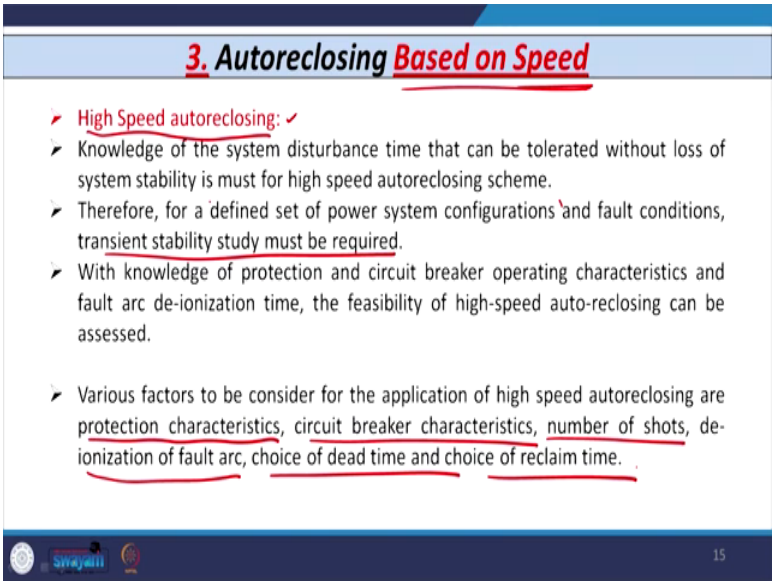
That means, if suppose if this fault is permanent in nature then whenever first reclosing attempt is made by this autoreclosers if this fault is permanent so again the relay operates it gives signal to the breaker, breaker again becomes open arc is quenched.

Once after completion of one reclosing attempt this remains in lockout condition that means in open condition, irrespective of whether the fault is permanent or transient. Sometimes if fault is transient then also relay operates once again, and once again breaker becomes open so then there is no other attempt that is to be carried out.

Now, in order to avoid the transient fault for long lines, particularly, transmission lines those are located in the vicinity where the chances of lightning surge that is very high particularly those located in hilly areas, then the single-shot reclosing relay that is preferred. On the other hand, multi-shot reclosing relays that is maybe two shot or three shot that is preferred in specified time interval, particularly, this is useful when we want to improve the continuity of power supply for the distribution network.

So single-shot reclosing relay that is used for a transmission line whereas, a multi-shot reclosing relay that is used for the distribution lines.

(Refer Slide Time: 22:17)



Now, let us see the third category that is based on the speed. So whether, we want to adopt high speed autoreclosers or whether we wish to carry out the delayed or low speed autoreclosing. Now, when we go for the high speed autoreclosing we know that the knowledge of the disturbance that occurs on the line or that is to be tolerated by the system or power system network that is very important, as far as the high speed autoreclosings are concerned.

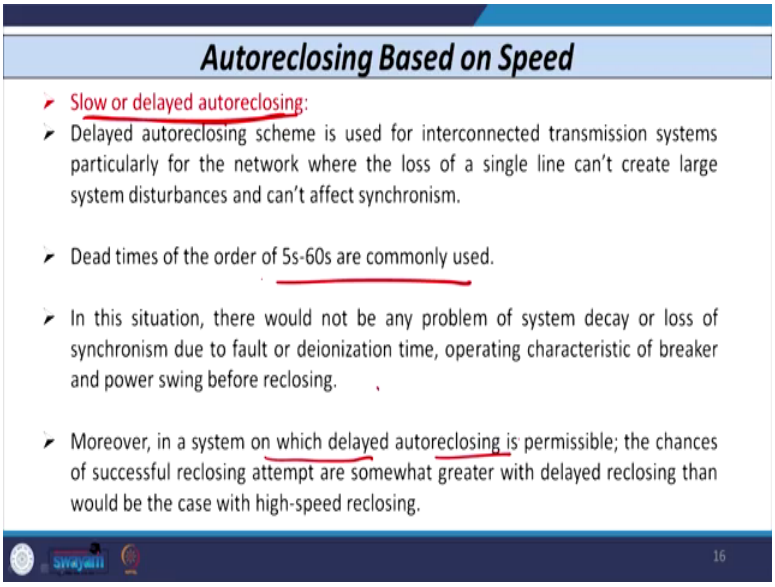
So, therefore, for a defined set of power system configurations and some fault condition before we go for the or before we adopt a high speed autoreclosers transient stability of the power system network that is must that means that is a prerequisite of the high speed autoreclosers.

So, with the knowledge of the relays and breaker operating characteristic and what is the deionization time of arc that means, within what time the, what is the marking time of the breaker, if we have the knowledge of that, then the feasibility of a high speed autoreclosing that can be easily assessed. So of course, when we go for high speed autoreclosing there are various factors that we need to consider.

And those factors are the protection characteristic, characteristic of the circuit breakers, so that also we need to know. The number of shot that means, whether we go for single reclosing attempt or multiple reclosing attempts, so this is also very important. Deionization time of the fault are that means within what time default that is full, that means the arc that is

fully quenched. So, this is also very important and the choice of dead time and choice of reclaimed time. This we will see later on what is the dead time and reclaim time.

(Refer Slide Time: 24:11)



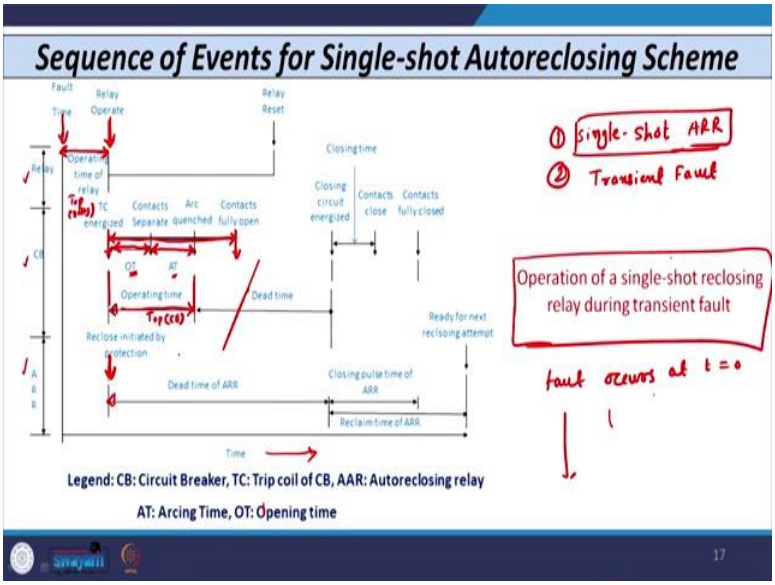
Now, let us see the next that is the slow or delayed autoreclosers. Delayed autoreclosing scheme is used particularly for the transmission system and specifically for the network where the loss of single line that can create a large disturbances on the synchronism. So, when we have a very interconnected power system network and if one line trips then there is a minimal impact on the synchronism of the whole network then at that time we can go for the delayed autoreclosing.

Dead time of the order of 5 to 60 second that is commonly used when we adopt the delayed autoreclosing scheme. Now, in this situation, there would not be any problem of the system decay or the loss of synchronism due to the fault or deionization time, operating characteristic of the breaker and power switch before the reclosing.

Now, moreover, in a system where we need to install the delayed autoreclosing the chances of successful reclosing attempt that is somewhat greater compared to the when we need to establish or install the high speed autoreclosing because if fault persists for longer duration, then that can be easily cleared by delayed autoreclosing system. So, that is the main difference between the high speed and delayed autoreclosing system.

Now, with this background, let us see what are the sequence of events that occur when we go for autoreclosers irrespective of whether we adopt high speed or whether we use single-shot autoreclosers or we go for the single-phase or three-phase.

(Refer Slide Time: 26:00)



Let us see what are the sequence of events that occurs for the autoreclosers. Let us consider that we use the single-shot autoreclosing relay, so we have used the single-shot autoreclosing relay. And let us assume that we are utilizing it for the, we are discussing this sequence of events for the transient fault. So, if I consider the transient fault and if I consider the single-shot autoreclosers, then this let us see, how the sequence of events occurs.

Now, here you can see on the X axis I have shown the time, whereas, on Y axis I have shown the 3 device one is the protective device or relay, it can be distance relay or some other relay, then the circuit breaker itself and the autoreclosers that is ARR. So suppose, let us assume that default occurs at let us say T equal 0 at particular instance say here let us say the fault occurs. So this is the inception of fault or occurrence of fault point.

Now as soon as fault occurs relay whatever relay you have used with the distance overcurrent that relay senses the fault and this relay depending upon the type of relay you have used it operates and it gives signal to the breaker. So this relay has some operating time, so this is the operating time of the relay.

So, once relay operates at this point after this much operating time maybe 20, 30 milliseconds then the it gives signal to the breaker, so the trip coil op circuit breaker that is energized at this instant and that I have shown on the circuit breaker part. Once the trip breaker of circuit breaker that is energized so its contact separate, so whenever its contacts start separating the breaker has the opening time.

So, this is the opening time of the circuit breaker, and then arch that is also established as soon as the contacts separates. So, some arching time of the breaker is also there. So, let us say this is the arching time of the breaker and after whatever medium you have used for the breaker when the arc is fully quenched, then the contact of the circuit breaker that is fully opened.

So, this total this total time that is known as the operating time of the circuit breaker. Basically, operating time of the breaker that is defined only from the instant where trip coil of circuit breaker is energized that is this to the instant when arc is fully quenched, so this is known as the operating time of the circuit breaker. So, this is your T operating of breaker and this is your T operating of your relay. So, this is very important. This is basically if you add this to you have the fault clearing time of the whole network or line in which fault occurs.

Now, you can see that whenever initially where protective device operates how the autorecloser know that, some event or something will happen. So, whenever relay protective device operates and it gives signal to the circuit breaker simultaneously it also gives signal to the auto reclosing relay, so auto reclosing really at the same instant when relay operate, it receives the signal from the autoreclosers.

So, whenever it receives the signal from the protective device, the work of autorecloser starts. So there is a time known as dead time of autoreclosers that starts from this instance that is this point.

So, in this class we have discussed, we started our discussion with the advantages of autoreclosers and then we have discussed the different types of autoreclosers based on number of phases, number of attempts and the speed and then we started discussion with the what are the sequence of events. If I use the single-shot autoreclosers and if I assume the transient fault which may die out after first reclosing attempt.

So, we have discussed few sequence of events. We will continue the same thing in the next class. Thank you.